U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY.—CIRCULAR No. 94.

A. D. MELVIN, CHIEF OF BUREAU.

FOOT-ROT OF SHEEP.

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[Reprinted from the Twenty-first Annual Report of the Bureau of Animal Industry (1904).]

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1906.

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HISTORICAL REVIEW.

Foot-rot was first described by Chabert in the year 1791 as existing north of the Pyrenees on the banks of the Gironde and lower Medoc. Later it spread to central France, and was described by Pictet in 1805 and by Gohier in 1808, both of whom declared it to be a communicable disease. It was likewise observed about this time in Piedmont, Italy, and spread into Germany about 1815 as a result of the introduction of French Merinos. Not only has it appeared in epizootic form in continental Europe, but it has also spread through Great Britain, Australia, and the United States, where it was not infrequently observed during the past century.

The date of its first appearance on American soil is unknown. The statement has frequently been made that the disease was brought to American shores by the colonists through importations of Spanish Merinos, and this statement seems to have been accepted by many writers without question or discussion. The first importation of Spanish Merinos for breeding purposes is reported to have been made in the year 1808, but the disease had become well established in this country prior to that time. Another reason for considering sheep from Spain very improbable as originators of the disease upon American soil is the fact that the sheep of Spain have been remarkably free from foot-rot. It is even asserted that it has never been seen on the dry table-lands which constitute the pastures of the entire region south of the Pyrenees. Spanish Merinos may have introduced the disease here, but it is very probable that they were first shipped from Spain to some other country, and thence, after a longer or shorter stay in their new home, reshipped, together with an infec-

[a] This paper is an abstract of Bulletin No. 63 of this Bureau.

tion of foot-rot, to America. It has been historically stated that the first settlers who attempted to establish flocks of sheep upon the prairie farms of Ohio, Indiana, and Illinois met with most disheartening experiences, which were in a measure due to the spread of foot-rot. In the year 1797 an agricultural settlement was made in Illinois by farmers from the eastern colonies, who brought with them flocks and herds of the sheep and cattle common to the section of the country whence they came. During the decade following many new homes were established in the prairie regions, and a number of the settlers brought with them foundation stock with the intention of growing large flocks of sheep, but wolves and panthers proved to be very destructive, and liver disease and foot-rot also hindered the establishment of large bands, until finally the pioneers were forced to be content with small flocks that could be constantly housed, guarded, and given careful attention.

The farmers of Maryland and Virginia were taking an increasing interest at this time in improved sheep. They had many discouraging conditions to contend with, and although it is possible that foot-rot was not known among their flocks at this time, it is certain that much trouble was caused by the appearance of "diseases, dogs, and wolves," and that contagious foot-rot made itself known and feared as early as 1832 in these States.

Owing to the imperfect knowledge at that time of matters pertaining to bacterial diseases, the sheep owners struggled against the spread of foot-rot in their flocks somewhat unsuccessfully, and it often required constant watchfulness and persistent treatment for three or four years to eradicate the disease after it had become thoroughly established upon the premises of the sheep grower.

Later than this, in the late fifties and early sixties, there was a marked revival of interest in sheep raising throughout the Middle West, and at this time many who had previously devoted their energies exclusively to grain or to cattle and hogs, concluded to change over to sheep, and the resulting traffic in these animals caused them to be moved about over the country roads and into new sections of the agricultural regions in numbers never before equaled. In several instances these traveling flocks carried foot-rot with them and infected the flocks with which they came in contact along their routes. The States of Ohio, Michigan (southern), Illinois, and Iowa were most seriously infected, and in all of them the disease secured such firm foothold that several years of strenuous combat were necessary before it was even partially subdued. It was during this period that a sheep raiser of long practical experience, in writing from his home State, Ohio, made the statement that farmers in his part of the country had in times past been seriously troubled by

the appearance of stubborn outbreaks of foot-rot among their flocks of sheep. In no case, however, had he been able to discover the spontaneous appearance of the disease, but with a little persistent inquiry it had been an easy task to trace the origin of each outbreak to the careless handling of diseased sheep brought from other localities. Since that time the disease has appeared frequently, but its spread has never assumed such alarming proportions, and, owing to a better understanding of the malady, it has been more successfully controlled.

SYMPTOMS AND LESIONS.

The first evidence of an attack of foot-rot to attract the attention of the shepherd is a slight lameness, which rapidly becomes more marked. Previous to this, however, there has appeared a moist area just above the horny part of the cleft of the foot, and this has gradually reddened and assumed a feverish, inflamed appearance. It may first become visible either at the front or back part of the cleft, but usually the erosions make their first appearance at the heel. The inflammation rapidly penetrates beneath the horny tissue, while from the ulcerous opening there exudes a thin, purulent fluid. The lameness has increased and the region of the foot above the hoof is becoming swollen and warm to the touch. The exudate from the erosions contains pus cells, bits of destroyed tissues of the foot, and bacteria. It possesses an odor pungent and disagreeable, but at the same time very characteristic. The experienced sheep man is frequently able to detect the presence of the disease in a flock of sheep, even though it be while making a casual visit to a strange flock, simply by means of the diagnostic and unmistakable odor which arises from the affected feet. This odor is so pathognomonic of the disease that it would reveal the presence of affected sheep to one familiar with the character of the infection, even before noticing the animals.

The erosion progresses, if no treatment is applied, and there is rapid formation of fistulous passages beneath the horny covering of the foot, while the softer tissues of the interdigital space are gradually becoming degenerated and purulent. The invading microorganisms possess marked burrowing propensities, and the result of their activity is that large areas of the hoof become loosened from the sensitive tissues lying beneath.

The invasion of the necrotic process may continue until ligaments, tendons, and even the bones are attacked; but before this final stage is reached nature will attempt to repair the damage, and for this purpose the secretion of formative elements in the injured part is greatly increased, until there appears a peculiar growth composed of horny elements, dense epithelial cells, and granulation tissue. These unsuc-

cessful attempts at renewed development of tissue are termed "fungoid growths," and they have been known to materially hasten the shedding of the horny covering of the foot by their persistent enlargement within the ulcerous channels cut by the advancing infective elements.

The hoof of a sheep suffering from a chronic case of foot-rot grows out rapidly and becomes very hard. It will often be found with the toes so thickened and lengthened that the front part of the foot is raised above its natural incline and the tendons at the heel are subjected to additional strain, all of which tends to increase the lameness and the awkwardness in gait of the victim. These thickened and

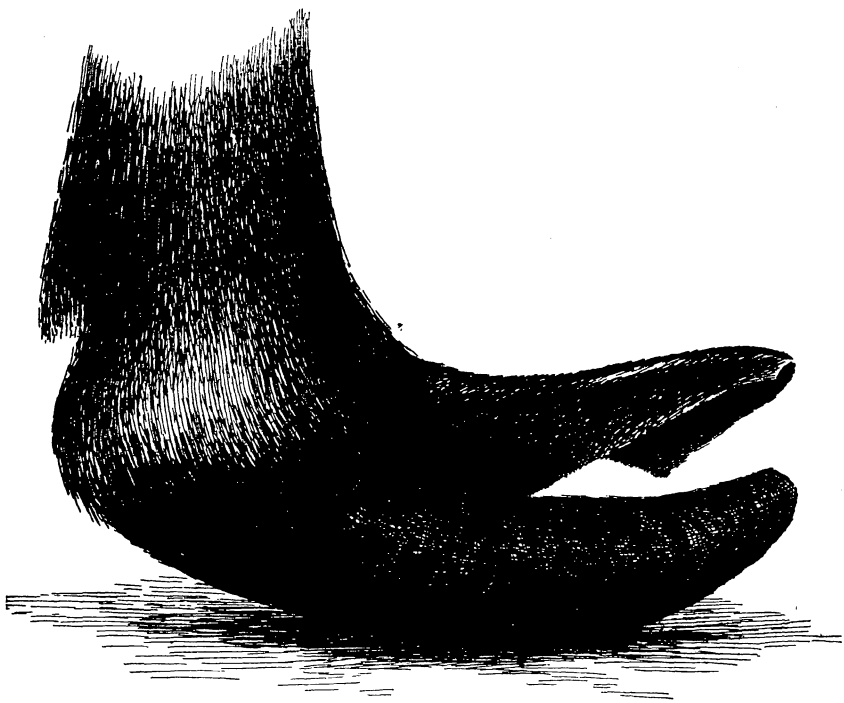

FIG. 1.—Hoof of sheep showing effects of chronic foot-rot.

elongated toes will frequently be seen to have attained an added length of 3 or even 4 inches, and they curl up like sled runners, greatly interfering with the progression of the animal. (See fig. 1.)

The sheep finds the act of walking so painful when the disease has become thoroughly established that it remains quietly lying in some secluded corner or, if diseased in the forefeet only, crawls around on its knees in its efforts to keep with the remainder of the flock or to get within reach of its food. Its temperature rises until there is evidence of considerable fever. The appetite is seriously impaired and the patient rapidly loses condition and weight.

During warm weather there is great danger of an attack by maggots as soon as the lesions are discharging freely, and unless these are quickly removed they will appear in such numbers as to rapidly bring the course of the disease to a fatal ending. They not only invade the affected feet, but will also locate at any point of the body at which the wool has become sufficiently contaminated by the purulent discharge from the ulcerous tracts to afford them a suitably moistened breeding place. The wool on the sides of the body is frequently more or less soiled from contact with the diseased feet while the animal is lying down, and it is in such areas that the fly deposits the eggs that hatch into destructive larvæ. As soon as the maggots are hatched they begin to burrow into the tissues upon which they are located and they quickly perforate the skin of their host, thus causing complications which bring its suffering to a close.

COURSE AND SUSCEPTIBILITY.

The course of this disease is slow and protracted, usually starting with one foot and subsequently involving one or more of the others. During this interval it would probably have likewise spread to the feet of other sheep, and in this way the disease may remain for several months in each member of the flock and for eight or ten months in the flock itself. When the ulcerous processes have become advanced and aggravated, fever develops, the appetite is lost, and the animal grows so emaciated that death intervenes. In some cases that are left untreated recovery may follow slowly, but there is usually either a dense fungoid growth between the claws, a stiffening of the joints of the ankle, or a long fissured and misshapen hoof. When treatment is properly applied in the early stages of the disease it is usually cured within ten days. It is very rare for death to occur as a result of foot-rot, although in very virulent outbreaks involving 3 or 4 feet of each sheep the affection may terminate fatally within two or three months.

The course of the disease is also dependent upon the susceptibility of the affected animal. Thus it is a well-accepted fact that the pure breeds of fine-wooled sheep are especially susceptible to foot-rot, although the pure breeds of coarse-wooled sheep and the grades of both of these breeds of animals are by no means exempt. In the latter animals, however, the disease runs a milder course, and is more amenable to treatment than in the case of the fine-wooled sheep. Sex or age does not appear to have any important influence on the susceptibility of the animals, as the disease manifests itself quite generally in the flock, attacking alike male and female lambs, yearlings, and aged sheep.

INFECTIVE CHARACTER.

Some of the early writers seem to have been convinced that this disease was in no degree contagious, but at a later period many investigators opposed this opinion and strongly maintained that it spread from sheep to sheep by means of some contaminating agent which exuded from the erosions upon the affected feet.

In opposition to these statements many veterinary writers were positive in their declarations that the disease was never caused otherwise than by pasturing on low, swampy lands, or as a result of overgrown toes or by other conditions due to faulty care and surroundings.

But while the majority of writers seem to have denied that the disease possessed any contagious properties, there remained a very lively minority who entered a most vigorous protest against this view of its character, and who cited instance after instance in support of their claim that it was strictly of a contagious nature. They mentioned cases in which affected sheep had been brought from a distance and placed in flocks that had been sound and healthy for years, with the result that a portion of the flock soon became affected; also a case in which healthy and diseased flocks pastured in adjoining fields without any transmission of the trouble until a time when two or three of the sound animals jumped the dividing fence and grazed for the remainder of the day with the contaminated flock, with the result that they promptly contracted foot-rot. These writers recorded the infection of sound flocks as the result of their having been driven over roads which diseased sheep had traversed but a short time previously. Reports were made of test lots of sheep that were pastured for months on swampy and muddy lands without spontaneous development of foot-rot, which promptly became affected, however, on their removal from these pastures when inoculated on the skin between the claws of their feet with discharge from an affected foot. They mentioned several attempts at experimental inoculation with bits of diseased tissue, or with some of the moist excretions from an affected foot, which usually favored the investigator with successful terminations.

One of the best of these experiments was reported by Favré in 1823. He simply moistened the skin between the claws of 32 healthy sheep with matter obtained from diseased feet, with the result that 21 of them contracted the disease in consequence of this slight exposure.

Another convincing argument in favor of the dependence of foot-rot on a specific cause is found in the fact that young lambs yeaned by affected ewes have been known to show unmistakable symptoms of the disease as early as the sixth day after birth, and as this has occurred in flocks that have been closely stabled there remains no possi-

bility that the lameness of these lambs could have originated in swampy or muddy pastures.

Among the first experiments made by this Bureau, preparatory to the publication of this article, were some for the purpose of investigating the contagious nature of the disease. By means of careful tests performed with the purulent exudate from the feet lesions of these animals it was proved that foot-rot could be produced at will in healthy sheep not only by spreading a little purulent matter from a diseased foot upon the scraped interdigital skin of sound feet, but quite as readily when bouillon cultures inoculated with some of the discharge from an affected foot were applied in a like manner, even when the cultures used were of the third generation of the original growth.

It appeared from these experiments that the disease was dependent upon a specific organism for its existence, and that this organism could be readily perpetuated by the employment of the usual methods of bacteriological culture.

Microscopical examination of the purulent material discharged from the open sore of a case of foot-rot revealed, among other bacteria, the constant presence of long thread-like bacilli, which conform to the characteristics of *Bacillus necrophorus*, and which are capable, when brought in contact with the foot of a healthy sheep, of producing sores similar to those found in natural outbreaks of foot-rot.

Wherever it gains access to animal tissue it causes progressive degeneration and destruction, showing a tendency to spread in every direction from its first point of attack, and leaving behind as it advances a soft, dead, cheesy mass as the result of its poisonous effect upon all contiguous tissues.

EXPERIMENT ON SHEEP.

The readiness with which the disease will spread from sheep to sheep, when the flock is kept under suitable conditions for such spreading, has been recognized for many years by sheep owners. In addition to the practical demonstration of its contagious character, which has been given in past years in nearly every sheep-growing State in the Union, many experiments have been made with the idea of determining the cause of the transmission of the disease from one sheep to another. For this purpose numerous direct inoculations with material from diseased feet have been made during this investigation, and in order to show the effect of pure cultures of the necrosis bacillus indirect inoculations have also been performed. A brief record of these two classes of experiments upon sheep will here be given.

Direct, by pus from affected foot.—Two sheep, Nos. 40 and 63, were

inoculated on the scarified interdigital skin with some of the exuded matter from an infected foot, and developed the disease in typical form in seven days in each case.[a]

Sheep No. 313 was inoculated with discharge from an infected foot on the shaven surface of the cleft of its foot. This was followed by the appearance of a characteristic inflammation on the ninth day, and the inflammation gradually developed into the usual course of ulceration seen in this disease.

Sheep No. 108 was inoculated upon the shaven surface of the skin of the foot with discharge from a diseased foot, following which a protective application of moist sterile cotton and a linen bandage was applied. A characteristic case of foot-rot developed on the fourth day as a result. It seems probable that the early appearance of the disease in this instance was brought about by the partial exclusion of air and by the retention of more or less moisture upon the treated surface, through the agency of the cotton and bandage.

Lamb No. 94 is of special interest, having been born in an infected stall in December, 1901, and having continued until March 10, 1902, in daily contact with diseased sheep without showing the slightest evidence of lameness. During this period of exposure the stall in which the animals were confined was kept dry and clean. Had mud and moisture been present for the animals to walk about in, in common, the result would doubtless have been different. This test was continued for seventy-nine days, at the end of which time it was seen that the healthy lamb had received no degree of infection, although the disease had slowly continued to advance in the feet of its diseased companions until the affected members had become deeply eroded. Following this preliminary test, the lamb was directly inoculated, on March 10, by the application of material taken from a diseased foot to both of its feet on the right side. The interdigital spaces of both feet were scraped until the surface became blood tinged, when the watery exudate from the diseased foot of sheep No. 62 was smeared over the scraped surfaces. There appeared on both of these feet in fifteen days characteristic lesions of foot-rot, while the left hind foot also developed this disease from natural infection, although the lamb had previously withstood the danger incident to living in daily contact with diseased sheep. It may be stated in this connection that other negative results were also met with by exposing healthy to diseased sheep, but although seven such experiments did not produce the disease these can in no way offset the positive results obtained, considering that the exposure pens were always clean and dry and unlike the natural conditions under which infection usually spreads.

[a] In many cases where foot-rot was produced by inoculation antiseptic treatment was applied and a cure effected as soon as the disease had become characteristic.

Indirect, by cultures.—A review of experiments made with pure cultures of the bacillus of necrosis will serve to show the part which this organism is capable of taking in the development of foot-rot in sheep.

A pure culture of the bacillus was obtained from the liver of a rabbit, which was the third in a series inoculated from the foot of an infected sheep. This pure culture was then applied to the scraped surface of a healthy foot of sheep No. 87. The surface upon which the culture was placed began to show inflammation on the tenth day, appearing reddened and moistened and exhibiting the presence of considerable heat. For ten days more the irritation appeared to progress, until at the end of that time a painful ulcer, coated with a grayish-white exudate, had formed. Spontaneous healing commenced at this period, but its progress was slow, and microscopic examination of the watery exudation from the ulcerous opening taken nearly two months later showed that many of the long filamentous forms of the necrosis bacillus were still present in it.

Another healthy sheep, No. 88, was inoculated upon the scraped surface of its foot with the same material as that used in the preceding case. The response was much more prompt (four days) in this case, and the ulceration penetrated the tissues of the foot for about the same depth, while the final healing, which occurred by scab formation, required about the same length of time for its establishment.

A third sheep, No. 89, to which the bacillus was applied in a pure state, showed inflammation of the foot in a few days and by the eighth day was sore and lame as a result. The erosion penetrated beneath the skin of the heels, constantly excreting foul-smelling yellowish pus. Spontaneous healing began to make its appearance in about three weeks after the inoculation, and rapidly progressed to the complete restoration of the foot.

A fourth test of a similar nature gave much the same results, except for a slight loosening of the hoof from a portion of one of the toes.

From the very nature of the conditions surrounding a flock of sheep it must be known that a natural infection by *Bacillus necrophorus* in a pure state is an utter impossibility. There must of necessity be material contamination by various cocci and other bacteria from the floor of the sheep pens, or from muddy yards and runs. Many of these invading forms in all probability offer great assistance to the necrosis bacillus in penetrating normal tissue and in perpetuating and extending the disease.

The character and appearance of the material discharged from a foot inoculated artificially with a pure culture of the bacillus of necrosis indicate that there is a slight difference between the disease when

produced in this manner and the natural type. The same redness of the surface is noted and the same tendency to send deepening processes of ulceration and degeneration into the depths of the foot may be observed in both, but the discharge will be seen to consist largely of soft yellowish pus in those cases in which the foot has been inoculated with pure culture and the foot afterwards kept dry and clean, while in the natural infection under ordinary barnyard conditions and in cases produced artificially by the application of mixed bouillon cultures the exudate has more of a yellowish-gray watery appearance mixed with pus.

There is no noticeable difference in the odor of the affected feet whether the lesions are produced naturally or artificially, and the same disagreeable stench pervades all cultures made from them, especially after these cultures have grown for forty-eight hours or longer in the incubator; and it is a remarkable fact that the same odor may be detected lingering about the carcass of a rabbit which has succumbed to an inoculation with necrosis bacilli in all cases, whether the bacteria were derived from cases of foot-rot in sheep or from some other source.

The following experiments were made with tissue containing an abundance of necrosis bacilli and with mixed bouillon cultures made from the pus of affected feet.

Sheep No. 83 was inoculated under the skin of the heel with material taken from the center of a necrotic lesion in a rabbit that died as a result of the infection of the necrosis bacilli. Here the attack was prompt and serious. The animal was unable to use its foot by the third day, and this degree of lameness lasted fully a week. The organism penetrated beneath the hoof on each toe, causing it to be separated in each instance from the tissues beneath. A profuse discharge was constantly exuding from the point of inoculation, in which the long threads of the necrosis bacillus could constantly be demonstrated.

Sheep No. 102 was inoculated on the foot by the application of a mixed bouillon culture that had been taken directly from a diseased foot and grown in an incubator for forty-eight hours, at a temperature of 35° C. Foot-rot was well established in the foot by the sixth day following, and its course was rapid and acute.

Goat No. 71 was successfully inoculated by having the skin of its interdigital space bared by the clipping off of the hair and the exposed surface then smeared with mixed bouillon culture of the third generation. As a result of this procedure the disease made itself manifest on the ninth day, and followed a typical course through the various stages of inflammation, spreading ulceration and necrosis.

ECONOMIC IMPORTANCE.

Throughout the Middle West, where packing houses are located in many of the larger cities, the sheep-feeding industry has attained large proportions. At points situated within easy reach of the more important slaughtering centers stations have been established for the purpose of finishing off those sheep and lambs that have been shipped from the ranges farther west before they had reached a sufficient degree of fatness to admit their being dressed to advantage. The stations are located within easy reach of several of the more important stock yards, thus enabling the owner to take advantage of a favorable turn in market quotations, or to supply any shortage that may occur in the receipts of a particular grade of sheep at the yards with which he is associated.

There are several of these places with a capacity of over 50,000 sheep each, and one near Chicago that can accommodate 80,000, as will be seen by the following list of feeding stations, the total of which shows that 683,000 sheep can be finished for market at one time. This list does not include the vast numbers of animals that are fed in the feeding stations of the far West, nor those in bunches of 500 to 3,000, by private individuals throughout the Central Northern States.

Partial list of sheep-feeding stations in the United States.

Location.	Capacity.	Location.	Capacity.
Grand Island, Nebr	25,000	Plano, Ill	25,000
Norfolk, Nebr	25,000	Specht, Ill	25,000
Nickerson, Kans	25,000	Rochelle, Ill	20,000
St. Marys, Kans	25,000	Milldale, Ill	15,000
Hanover, Kans	8,000	Oswego, Ill	15,000
Columbus, Nebr	25,000	South St. Paul, Minn	40,000
Valley, Nebr	35,000	St. Anthony Park, Minn	60,000
Fremont, Nebr	25,000	Brighton, Minn	25,000
Stockdale, Ill	60,000	Trevor, Wis	25,000
Lafox, Ill	60,000	Total	683,000
Montgomery, Ill	80,000		
Kirkland, Ill	40,000		

It is customary to keep the animals closely penned during the period of their fattening at these establishments; in fact they are sometimes restricted to rather uncomfortably narrow quarters. They are divided into lots of 200 to 600, to suit the convenience of the feeder, and each lot is provided with a separate pen in which they remain from the time of their arrival until sufficiently finished to warrant the continuance of their journey to the packing house. In many cases their grain is supplied to them through "self-feeders," by which means a supply is kept constantly before them. Water is also available at all times, and the incentive to active exercise is very slight,

even if the pen were large enough to allow unrestricted movements. Under these conditions an outbreak of foot-rot quickly assumes serious proportions. While the disease will not of necessity spread from one pen to an adjoining one, there are several cases on record where the contagion has been so thoroughly disseminated among individual pens in which a few infected sheep have been placed that only a small number of its inmates escaped the attack. Inspectors of the Bureau of Animal Industry, United States Department of Agriculture, occasionally find an affected flock among the arrivals of sheep at the various railway terminals, in which the feet of as many as 75 to 80 per cent are diseased to a greater or lesser extent. These bunches of sheep have no doubt been run together in the feeding pens, and the percentage of diseased animals gives one a very good idea of the infectiveness of foot-rot under these conditions.

The sheep raiser or feeder who carries on his business upon a modest scale is often just as seriously injured by an outbreak of foot-rot in his flock as is anyone. His sheep run at will over a large portion of his farm, and it soon becomes so thoroughly contaminated by the repeated passage of diseased feet that the owner not only becomes thoroughly discouraged by the repeated failures of his attempts to eradicate the contagion from the premises, but his neighbors begin to look on him with suspicion, and in certain instances have become so aroused as to warn the unfortunate man against entering upon or crossing their holdings until he has succeeded in stamping out the dreaded plague.

The importer or breeder of choice registered sheep is frequently damaged materially by the appearance of this disease among his valuable animals. Foot-rot occasionally develops in sheep soon after importation from European countries in spite of careful examination at the time of purchase. In these cases it is probable that the virus had become lodged in some deep fissure under the horny covering of the foot during some previous exposure, and that it had remained latent in its hiding place until favoring conditions stimulated its growth.

Whatever the manner of propagating the infecting agent, the fact remains that foot-rot frequently manifests itself among flocks of blooded sheep while on shipboard on the way to this country, and conditions here favoring the spread of the infection from sheep to sheep, it is not uncommon for the animals of certain pens to show serious lameness by the time the port of debarkation is reached. Another place in which the owner of improved sheep expose his best specimens to more or less danger of infection is at the live-stock shows of the country, where his animals are exhibited side by side with sheep from widely scattered localities. This danger, however, is

reduced to a minimum by the excellent care given to both animals and pens while the exhibition is in progress. The greatest danger is probably met when the animals are loaded and unloaded over a chute at the railway station, which is used by all of the exhibitors in common.

The raising of Angora goats is also becoming an industry of great economic importance. Their value as producers of mohair, of fleece-bearing skins, and of meat, together with their efficiency as eradicators of brush and weeds, is bringing them into increasing favor with practical American people, while their beautiful silky coats and gentle dispositions make them very attractive as pets for those who seek to derive pleasure rather than profit from them. At the present time large sums of money are invested in these animals, and individual flocks numbering thousands of animals are not uncommon in some localities. An association of breeders has been formed which supports a registry book, and live-stock exhibitions at which the Angora forms a prominent feature are sure to attract general interest.

The experiments which have been made at this laboratory prove that Angora goats may readily be inoculated with foot-rot from sheep, and that where sheep and goats are allowed to pasture together they may be indiscriminately attacked by an invasion of this disease.

To what degree foot-rot exists among sheep and goats in this country can not be accurately stated, for the reason that our statistics are insufficient to furnish a basis for a reasonable estimate. Occasional outbreaks, especially the highly virulent ones, are reported, and in these cases about three-fourths of the flock become affected. Owing to the slow, protracted course of the disease and the length of time required for the affection to pass through a bunch of sheep, the losses occurring from the shrinkage of flesh in market sheep and from the diminution of the supply of milk for the sucking lambs of the affected ewes reach material proportions. In addition to these direct losses, the owner of an infected flock of full-blooded animals is subjected to discouraging failures in his attempts at selling off his surplus breeding stock, as buyers are naturally reluctant to introduce lame animals into their sheep-folds. The time and labor spent in the treatment of the feet of an infected flock should also be brought forward in this calculation of monetary loss.

DIFFERENTIAL DIAGNOSIS.

There are but few pathological conditions of the feet of sheep or goats that may be mistaken for contagious foot-rot. When lameness first makes its appearance in a flock there may some difficulty, how-

ever, in determining the exact nature of the trouble. Lameness may be primarily caused in these animals by wounds of the feet, by purulent inflammation of the interdigital space (so-called noncontagious foot-rot), by stoppage of the orifice of the biflex canal, by suppurative cellulitis (cutaneous abscesses), or by foot-and-mouth disease, and for a time the lesions produced by any one of these causes may offer a very confusing resemblance to those characteristic of the invading stage of foot-rot.

WOUNDS OF THE FEET.

Sheep may occasionally puncture the skin of the interdigital space by forcing a sharp stone or stub between the claws of the foot, but such accidents are infrequent, and the fever and lameness thus produced seldom last for more than a few days.

A more common cause of accidental lesions to the feet of sheep is found around some yards or stables, where loose boards with the points of nails sticking up from their surfaces are carelessly left for the flock to run over.

PURULENT INFLAMMATION OF THE INTERDIGITAL SPACE (FOULS).

This condition is one that is frequently met in sheep, and it has often been mistakenly called foot-rot. From this faulty naming has arisen much of the controversy over the question of the contagiousness of foot-rot. Parties who have had experience only with purulent inflammation of the foot, and who have looked upon it as foot-rot, have very reasonably asserted that foot-rot is by no means contagious, that it appears sporadically, may attack but few members of the flock, yields promptly to treatment, and nearly always makes its appearance among sheep during their pasturage upon low, swampy land. If the term foot-rot is used at all in connection with purulent inflammation of the feet, it should be qualified by calling the affection benign or noncontagious foot-rot, in order to avoid all confusion with the real or contagious form of the disease. This purulent inflammation may result from pasturing on wet, filthy grounds or on low, marshy lands. An irritation of the cleft of the foot occurs which is followed by fissures in the skin and a softening of the horn resembling foot-rot. In rainy weather sheep that are pasturing upon clay soils often accumulate irritating masses of twigs, stubble, or small, sharp pebbles in the interdigital space of the foot. These substances become thoroughly embedded in moistened clay, and this mixture is gradually molded to the form of the space between the claws of the foot. In this position it will remain for days unless removed by force, and it may be the cause of serious inflammation, suppuration, and lameness so long as it retains its position in this sensitive place. Each step of the animal

causes the projecting points of the offending material to cut deeper and deeper into the adjoining tissues of the foot. There ensues swelling above the coronet and the whole of this region becomes reddened and feverish. Cases have been noted where marsh grasses with their saw-like edges have become entangled in the cleft of the foot and have remained in position long enough to set up a painful irritation by their constant friction. Finally, on examining the foot of a lame sheep one may discover the presence of none of these pointed objects, and still the inflammation is intense. This condition has been known to follow the entrance of particles of sand and gravel into the cuts, cracks, or injuries, and one should always bear this in mind while looking for a cause for lameness, and carefully remove the grit or dirt which may be present. Sometimes the horn, having grown rapidly because of the unusual stimulation, may inclose the gravel and retain it within the foot as a constant source of irritation.

STOPPAGE OF THE BIFLEX CANAL.

Sheep and goats are provided with a secretory gland called the interungulate or biflex, situated among the tegumentary tissues of the leg just above the separation of the digits. The orifice of the little vessel that leads from this gland may be plainly seen upon spreading the toes apart. It occasionally happens that mud, sand, or some other gritty substance becomes forced up into the biflex canal and lodges there, not only choking up the excretory passage of the gland above, but also causing inflammation of the walls of the canal, which may develop into extensive suppuration and serious lameness.

This affection may be distinguished from contagious foot-rot by the fact that the ulceration does not tend to invade the tissues beneath the horny covering of the foot, nor does it assume an infectious character.

SUPPURATIVE CELLULITIS (CUTANEOUS ABSCESSES).

Stockmen whose sheep are obliged to pass daily through muddy yards or pens sometimes notice the eruption of sores, varying in size from the diameter of a millet seed to that of a silver dollar, just above the hoof, farther up on the ankle, or still higher up between ankle and knee.

The first indication of the trouble will be an erection of the hair over the affected area, quickly followed by swelling of the part, and accompanied with a marked rise of temperature in the animal, loss of appetite, sluggishness, and rapid wasting of condition.

As the disease advances each of the inflamed areas develops a typical abscess, containing creamy pus with a very offensive odor. Should any of these find lodgment in the tissues of the foot they may

be mistaken at first for indications of foot-rot, but the simultaneous appearance of similar abscesses beneath the skin of the leg will at once prove to the owner the nature of the trouble.

FOOT-AND-MOUTH DISEASE.

This country, most fortunately, has never experienced a serious outbreak of foot-and-mouth disease in sections in which the sheep industry forms an important factor in agricultural activities. It is one of the scourges of European countries, and the annual reports of outbreaks of contagious diseases in those lands show what a firm footing the disease has gained among their flocks and herds.

Should an invasion of this disease ever be mistaken for foot-rot in sheep, the illusion will not be one of long duration. The eruptions which appear upon the feet of sheep in an attack of foot-and-mouth disease may, during the invasive period of the outbreak, bear a close resemblance to those of foot-rot, but they are more superficial in their effect, being devoid of the deep-seated, erosive passages which characterize the foot-rot lesion, and for this reason they are far more transient, disappearing voluntarily when the disease has run its course in all cases in which the attack reaches a favorable termination. The lesions of foot-and-mouth disease are more plainly to be seen, the destructive processes frequently extending up above the cleft of the foot in front or rear into plain view of the examiner. In uncomplicated cases there is never any tendency to fungoid growths, and the structure of the hoof retains its normal formation and does not become soft or crumbling, as it frequently does after an attack of foot-rot. The primary attack of foot-and-mouth disease is usually evidenced by the simultaneous affection of at least three of the feet of the animal. The infection spreads more rapidly through the flock, and not to the sheep alone, but to the cattle and hogs which are permitted to mingle with them. In addition to the eruptions on the feet the sheep suffering from foot-and-mouth disease will occasionally show reddened patches upon the membranes of mouth and lips which speedily develop into blisters of varying sizes. The tongue may be affected in the same manner. These blisters soon rupture, leaving raw, open sores. The teats and udders of affected ewes are frequently the seat of like eruptions. The temperature of the animal shows marked elevation during the invasion of the trouble (106° F.), but this does not persist after the rupture of the vesicles. Lesions of the mouth are not as constant in sheep as they are in members of the bovine family.

A number of European writers have in the past insisted that contagious foot-rot of sheep does not exist independently of foot-and-mouth disease, but the very fact that contagious foot-rot has for

years been more or less prevalent among American sheep without ever having given rise to foot-and-mouth disease among the cattle and hogs of the same farms offers the most conclusive evidence that the diseases are independent of one another and that they have their origin in separate, specific organisms.

PREVENTION.

The prevention of foot-rot, a matter of absorbing interest to the sheep owner, may be successfully attained by means of careful management.

When purchasing sheep to be added to a healthy flock the buyer can not exercise too great caution in his examination of the newcomers, and to hold them for a few days in isolated quarters before permitting them to join the main flock may prove to be time and effort well spent. Another precaution which will in some cases prove beneficial may be found in the regular examination at stated intervals of the feet of each member of the flock and the removal of all excessive growths of horn. A large percentage of lameness in the horse is due to an "unbalanced foot," and the first step in treatment should always be the paring of the hoof, or the formation of the shoe in such a manner that the foot of the horse, while he is standing at ease, will be perfectly level in its relation to the floor surface upon which he is standing. The same rule holds good in an application to the ovine race. Overgrown hoofs should be so trimmed that the plantar or wearing surface of the foot will present a natural angle to the direction of the shaft of the leg, and all superfluous length of toe should be removed. Overgrown toes frequently tend to forcibly spread the hoofs apart, the tension thus produced leading in many cases to strained tendons and to lessening the natural resistance of the tissues of the region to injury.

A great amount of vital energy is unnecessarily expended in walking by a sheep with overgrown toes, especially if the animal is kept in yards or pens where cornstalks or other coarse litter are allowed to accumulate, or if it is pastured in stubble fields or where the grass has become long and tangled.

The heels of the hoofs seldom require any cutting, and the labor of trimming may consequently be entirely expended upon the toe. Soaking the feet for a time will be found to soften hoofs that are at first too hard to yield readily to the knife. It will be found satisfactory, where practicable, to select a time for trimming the hoofs when the flock may be brought up to the pens directly from an excursion through wet grass. The early morning, following a heavy fall of dew, is frequently selected for this purpose, or the work, if not neglected too long, may be deferred until a suitable rainy day.

Should the infection of foot-rot have been introduced into a sheep yard, trimming the feet will not prevent the spread of the disease, except as it indirectly assists nature in keeping the cleft of the foot free from dirt, and the wise shepherd will not relax his vigilance at the time of admitting fresh arrivals upon his premises, as it is at that time that he may most easily prevent the spread of this disastrous malady among his healthy animals.

Experience has shown that sound sheep may be safely pastured on land that has previously been occupied by sheep suffering from foot rot, provided that a winter's frosts have been allowed to intervene. The contagion of the disease seems to be effectively subdued by this means, and pastures that have become contaminated one season may be considered safe for their customary usage during the following season. The sheepfold, however, must be carefully disinfected to prevent the recurrence of the disease, as this bacillus will retain its virulence under suitable conditions in or around stables for several years.

The walls, racks, and troughs should be sprinkled with a solution containing 1 pound of pure carbolic acid to 5 gallons of water, to which enough lime has been added to make the sprayed area conspicuous. The manure and 4 inches of the surface soil should be removed and spread on a field that is to be tilled. In turning sheep on grass care should be taken to avoid low, marshy, or boggy lands, and to keep them, if possible, on high, dry pastures.

TREATMENT.

One of the first steps to be taken in the treatment of a flock of sheep affected with foot-rot is to separate all that are in any degree diseased from those that are healthy. After this has been accomplished much will depend upon the stage which the disease has reached among the animals of the flock in determining upon further action. Should the disease be in its earliest stage, with but few animals affected, it will doubtless be found sufficient treatment for those that appear sound to pass them through a shallow trough containing a solution composed of 1 pound of chloride of lime to each 12 quarts of water. This solution should have a depth of at least 4 inches in the trough, and the animals should be made to pass through it slowly, allowing time for the mixture to apply itself thoroughly to all the cracks and fissures of the feet. Instead of the mixture of chloride of lime, a solution composed of one part of carbolic acid crystals to every thirty parts of water, or 1 pound of pure carbolic acid to 4 gallons of water, may be used as a foot bath for the sound part of the flock.

The trough used in this operation may be of wood, tightly con-

structed, 20 inches in width, and a foot or more in depth. The length should be proportioned to the size of the flock to be treated. For small lots that are accustomed to being handled, the trough need not be over 6 feet in length. In such cases, however, the animals should be allowed to stand for a moment in the solution before passing out. A greater length of trough would necessitate the preparation of a larger amount of fluid, and consequently would entail greater expense. Where a large number of sheep is to be treated the trough should not be less than 20 feet in length. Hurdles or portable racks may be so arranged by the sides of the trough and along the pathway leading to it that each animal will be obliged to pass through the bath with but little urging.

After this treatment has been applied to the sound part of the flock, they should be at once placed in fresh, uncontaminated quarters. Although they are not likely to show any evidences of the disease after being treated in this way, the owner or shepherd should not neglect them, but should closely watch for any signs of lameness, and when discovered the affected animals should be promptly removed and subjected to more careful treatment. In case the flock from which the healthy sheep were separated is badly diseased, it would be advisable to have the sound animals pass through the bath, as described above, on several occasions. This may be done every second day until three or four treatments have been applied, special care being taken in the meantime to provide fresh, clean quarters for the animals, completely separated from the diseased portion of the flock.

While selecting treatment for that portion of the flock in which the disease has become established, it should be remembered that the principal requisites are to lay bare the affected surfaces and to destroy the infectious matter which has lodged upon them. The remedy which will accomplish this most readily, and at the same time not give rise to harmful secondary conditions, is evidently the one that should be given the preference.

The bacteria, to which the disease is due, yield very readily to the application of disinfectants, and the trouble which so many sheep men have experienced in the eradication of foot-rot from their flocks must have been due to a failure to properly expose the affected surfaces to the action of the applied remedy.

During the present series of experiments many of the feet in which disease has been purposely produced have been healed up as soon as the true course of the affection had become evident, so as to avoid unnecessary lameness, and in these cases it has been found that all advance of the disease processes has promptly stopped upon the application of a 5 per cent solution of carbolic acid, several applications usually proving sufficient. In these cases, however, it

must be admitted that the conditions for successfully healing the lesions were far more favorable than those which surround the average diseased flock upon the farm. In the first place, the erosions had not extended very deeply into the foot, and, secondly, the animal was not allowed to run in a muddy yard, but was kept upon a dry stable floor. The instances serve to prove, however, that the remedy need not be very poisonous or caustic to produce the desired results, and to emphasize the fact that one must constantly aim, while treating foot-rot in sheep, to expose the diseased areas to the action of the disinfectant used.

Treatment of the affected animals should not be deferred, as more satisfactory results will be obtained by attacking the outbreak as soon as discovered than can be expected if the disease is permitted to spread among the flock or to penetrate deeper into the tissues of the affected feet. This is accepted as a very practical fact by the English shepherds, who attend shipments of thoroughbred sheep on their trans-Atlantic voyage to this country for breeding purposes. The statement is made by them that none but negligent or inexperienced shepherds will ever allow foot-rot to spread through a flock of which they are in charge, as thorough trimming and antiseptic treatment of the hoof of the first animals seen to be lame will surely save the balance of the sheep from an attack.

The treatment already suggested for the sound portion of the flock will be found very efficacious for early stages of the disease, but after the animal has become more seriously affected one should carefully examine each of its feet and, if necessary, pare away all shredded or loosened portions of the horny tissue. This will often prove to be a very laborious undertaking, but the operator should persist until the loosened horn has been thoroughly removed and all of the ulcerous fissures have been exposed.

The foot must be carefully cleaned and every portion of loosened and detached horn cut away, as the horny tissue once separated from the sensitive parts beneath will never unite with them again, but will remain as a source of pain and inflammation and also a protection for the disease-producing organisms while they attack and destroy the internal structures. Should fungoid granulations be met they should be removed with a knife or pair of curved scissors. All clippings and trimmings that are removed from the diseased feet, whether composed of bits of horn, shreds of tissue, or fungoid growths, should be carefully gathered up and burned or disinfected, as they may serve to spread the disease further if left where passing sheep may come in contact with them.

If this work has been thoroughly done, standing a sheep for ten minutes in a strong solution of copper sulphate (blue vitriol), made

as warm as can be borne by the hand, will in most cases effect a cure. This solution may be prepared by dissolving 3 pounds of copper sulphate in 5 gallons of warm water. The foot bath should be repeated if necessary.

An attendant should remain stationed by the side of each sheep whose feet are badly affected, to prevent the animal from lying down while it is in the copper-sulphate solution, as sheep of this class, because of the pain produced during their efforts to stand, are liable to drop to their kness, or even to lie down in the trough, during the application of the treatment. Soft bandages should be applied, after the sheep are removed from the foot bath, to all feet that have required deep cutting, not only for the purpose of protecting the sensitive tissue from becoming bruised, but in order that particles of dirt may be kept from the raw surfaces and that nature may be assisted in the formation of new protective coverings.

It sometimes happens that the disease assumes an aggravated form in several of the sheep, involving the deeper sensitive tissues and necessitating the application of hand dressings to the feet. In such cases all the loose and diseased tissue should be cut away and the affected parts washed thoroughly with a 5 per cent solution of carbolic acid. An antiseptic astringent powder, consisting of 4 parts of carbolic acid, 2 parts of tannic acid, and 94 parts of exsiccated alum, is then dusted upon the ulcerated surfaces and a bandage applied to afford the parts the desired amount of protection.

The most earnest efforts should be made to conquer the disease before the advent of warm weather, as it will be found more difficult to deal with during that period. On the contrary, cold weather and dry seasons are unfavorable for the development or spread of the disease, although they will not cure it.

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